

Ultra-stable, Diode-pumped Nd-doped Glass Regenerative Amplifier for the National Ignition Facility (NIF)

J. K. Crane
M. Martinez
R. J. Beach
S. Mitchell
G. Pratt
J. J. Christensen

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Ultra-stable, diode-pumped Nd-doped glass regenerative amplifier for the National Ignition Facility (NIF).

John K. Crane, Mikael Martinez, Raymond J. Beach, Scott Mitchell, Garth Pratt, and
John J. Christensen

L-490, Lawrence Livermore National Laboratory, P. O. Box 808, Livermore, CA 94550

We describe a diode laser-pumped Nd:glass regenerative amplifier that amplifies temporally shaped pulses with low distortion, high pulse-to-pulse stability, and high gain. This laser amplifier is a prototype subsystem for the National Ignition Facility (NIF) laser system.

The large, Nd-doped laser system for the National Ignition Facility (NIF) is comprised of 192 separate beam lines that each produce about 10 kJ of 1.05 micron light. Simply stated the architecture consists of a central, all-fiber master oscillator system, where the light is generated, shaped, modulated, and distributed to 192 beam lines. Next, 192 preamplifier modules amplify the tailored pulses from 1 nJ up to 10 J, whereupon they are transported to the large amplifier chains where the laser energy is increased to the 10 kJ level. The preamplifier modules contain a regenerative amplifier (regen) and a larger four-pass amplifier. The design specifications for the regen include a total gain of 10^7 , an output energy of 10 mJ, operating at a 1 Hz pulse repetition rate, a square-pulse distortion < 1.2 , a signal-to-noise ratio $> 10^4$, and a pulse-to-pulse output energy stability of better than 3%.¹ In this paper we describe the current design and performance of a long pulse regenerative amplifier that uses two, diode array, end-pumped Nd-doped glass amplifiers to achieve the desired performance.

The regenerative amplifier is a folded linear arrangement, shown in Fig.1. The 4.5 m. long cavity has a 2 m. lens and mode limiting aperture positioned near the midpoint. The cavity is designed to operate with a single spatial mode and yields a 1.2X diffraction limited output beam as measured by our output farfield camera. At either end of the cavity is a Nd-doped glass rod amplifier that is end-pumped by a 48 bar diode array. The diode light is efficiently collected with a micro-lens array and propagated through a tapered lens duct that funnels light down into the end of the 5mm diameter laser rod.² Each rod stores about 300 mJ of energy in the upper laser state from 2 kW of optical pump power in a 350 μ s pulse. The total available energy in the cavity eigenmode is about 60 mJ.

The input to the regenerative amplifier is a temporally-shaped, phase-modulated, 1 nJ pulse of 20 ns duration. This shaped input pulse arrives from the fiber master oscillator system and is mode matched to the regen cavity using a two lens telescope. The s-polarized input pulse is introduced into the cavity via reflection from a thin film polarizer. After one round trip the first Pockels cell is turned on, trapping the pulse in the cavity for the desired number of round trips. We operate the regen with a net round trip gain of between 3-4. After 13-15 round trips through the cavity the input signal is amplified to the desired energy, about 10 mJ, and we switch the pulse out by energizing the second Pockels cell.

We measure the pulse buildup in the cavity as a function of round trip and compare with a Frantz-Nodvik model and determine the net round trip gain and loss. These measurements also reveal the amount of square-pulse distortion as a function of gain and number of round trips. We determined the ratio of amplified input signal to the amount of amplified spontaneous emission (ASE) by comparing the pulse buildup in the cavity when the input seed is blocked and unblocked and found a value for S/N of 2.7×10^4 . To determine the gain stability of our regenerative amplifier we measure the ratio of output energy to input seed energy for several thousand shots. To understand the sources of gain fluctuations we simultaneously monitor the diode current, diode fluorescence, rod fluorescence, temperature, and output beam pointing. To date we have measured gain stability, $\Delta G / \langle G \rangle$ as high as 0.4% for 4000 shots while operating the regen at the NIF specifications for output energy and gain saturation.

1. National Ignition Facility Conceptual Design Report, UCRL-PROP-117093, Vol 3, May 1994.
2. R. Beach, P. Reichert, W. Bennett, B. Freitas, S. Mitchell, S. Velsko, J. Davin, and R. Solarz, "Scalable diode-end-pumping technology applied to a 100 mJ, Q-switched Nd³⁺:YLF laser oscillator", Opt. Lett. **18**, 1329 (1993).

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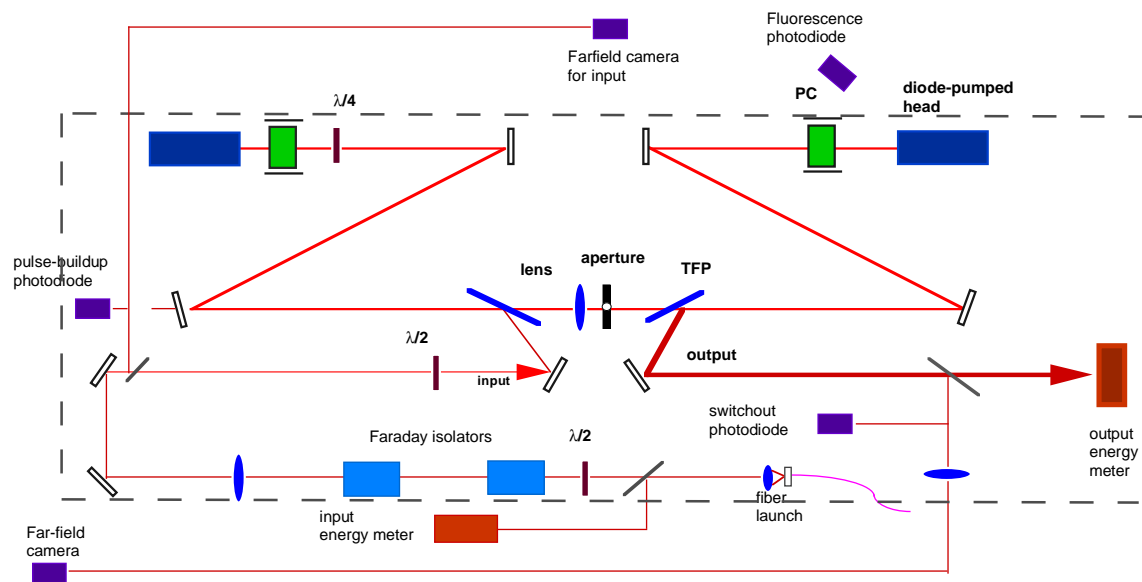


Figure 1. Layout of the NIF regenerative amplifier showing cavity, injection optics, and various diagnostics.